WHAT IS CLAIMEED IS:

1. A piezoelectric element structure comprising:

a supporting substrate; and

a piezoelectric film supported on said supporting substrate,

wherein said piezoelectric film contains a first layer, and a second layer having zirconium, each provided with perovskite structure, and formed to be in contact with each other or laminated through an intermediate layer, and the temperature at the time of thin film formation is 500°C or more to provide said piezoelectric film, and for the formation thereof, a quick cooling is given from the thin film formation temperature at least to 450°C with a cooling speed of 30°C/min or more.

2. A piezoelectric element structure according to Claim 1, wherein said first layer does not contain zirconium.

3. A piezoelectric element structure according to Claim 2, wherein said intermediate layer is in contact with said first layer and said second layer to reside between these layers, and the zirconium concentration increases inclinatorily.

4. A piezoelectric element structure according to

Claim 1, where the amount of zirconium content of said first layer is smaller than the amount of zirconium content of said second layer.

5. A liquid discharge recording head comprising:

a main body portion provided with liquid discharge ports, and pressure chambers connected with said liquid discharge ports;

a piezoelectric film having lead, titanium, and zirconium; and

a piezoelectric vibrating portion provided partly for said pressure chambers containing electrodes arranged for both sides of said piezoelectric film, said vibrating portion being made to perform warping vibration to discharge recording liquid from said liquid discharge ports,

wherein said piezoelectric film contains a first layer having no zirconium, and a second layer having zirconium, each provided with perovskite structure, and formed to be in contact with each other, and the temperature at the time of thin film formation is 500°C or more to provide said piezoelectric film, and for the formation thereof, a quick cooling is given from the thin film formation temperature at least to 450°C with a cooling speed of 30°C/min or more.

6. A liquid discharge recording head comprising:

a main body portion provided with liquid discharge ports, and pressure chambers connected with said liquid discharge ports;

a piezoelectric film having lead, titanium, and zirconium; and

a piezoelectric vibrating portion provided partly for said pressure chambers containing electrodes arranged for both sides of said piezoelectric film, said vibrating portion being made to perform warping vibration to discharge recording liquid from said liquid discharge ports,

wherein said piezoelectric film contains a first layer and a second layer, each provided with perovskite structure, and formed to be in contact with each other, and the amount of zirconium content of said first layer is smaller than the amount of zirconium content of said second layer, and then, the temperature at the time of thin film formation is 500°C or more to provide said piezoelectric film, and for the formation thereof, a quick cooling is given from the thin film formation temperature at least to 450°C with a cooling speed of 30°C/min or more.

7. A liquid discharge recording head comprising:

a main body portion provided with liquid discharge ports, and pressure chambers connected with said liquid discharge ports;

a piezoelectric film having lead, titanium, and zirconium; and

a piezoelectric vibrating portion provided partly for said pressure chambers containing electrodes arranged for both sides of said piezoelectric film, said vibrating portion being made to perform warping vibration to discharge recording liquid from said liquid discharge ports,

wherein said piezoelectric film contains a first layer having no zirconium, and a second layer having zirconium and an intermediate layer with the zirconium concentration thereof to be inclinatorily increased, each provided with perovskite structure, and formed to be in contact with each other, and the temperature at the time of thin film formation is 500°C or more to provide said piezoelectric film, and for the formation thereof, a quick cooling is given from the thin film formation temperature at least to 450°C with a cooling speed of 30°C/min or more.

8. A liquid discharge recording head according to Claim 5, wherein the ratio of zirconium/titanium in said second layer is set at 30/70 or more and 70/30 or less.

9. A liquid discharge recording head according to Claim 5, wherein said piezoelectric film is mono-

orientational crystal or monocrystal.

10. A liquid discharge recording head according to Claim 5, wherein said piezoelectric film is formed with orientation in the direction (100).

11. A liquid discharge recording head according to Claim 5, wherein said piezoelectric film is orientated in the direction (111), and the said electrodes are comb-shaped or formed on the entire face.

12. A liquid discharge recording head according to Claim 5, wherein said piezoelectric film is formed in a thickness of 10 μm or less.

13. A liquid discharge recording head according to Claim 5, wherein said piezoelectric film is formed in a thickness of 1 μm or more and 4 μm or less.

14. A liquid discharge recording head according to Claim 13, wherein the first layer of said piezoelectric film is formed in a thickness of 30 nm or more and 100 nm or less.

15. A liquid discharge recording head according to Claim 5, wherein said piezoelectric vibrating

portion is provided further with a vibrating plate.

16. A liquid discharge recording head according to Claim 15, wherein said vibrating plate is formed by at least one of materials or a laminated member of the materials selected from nickel, chromium, aluminum, titanium, zirconium, and from the group of oxide thereof or nitride thereof, silicon, silicon oxide, polymer organic materials, and YSZ.

17. A liquid discharge recording head according to Claim 15, wherein said vibrating plate is formed with the vibrating plate characteristics by ion injection on the upper part of the main body substrate to form pressure chambers.

18. A liquid discharge recording head according to Claim 15, wherein said vibrating plate is formed on a silicon monocrystal substrate with epitaxial development.

19. A liquid discharge recording head according to Claim 5, wherein the second layer of said piezoelectric film contains niobium and tin, manganese, and provides antiferroelectricity.

20. A liquid discharge recording head according

to Claim 5, wherein the electrode layers arranged for both side of said piezoelectric film are formed by platinum, iridium, conductive oxide, or conductive nitride.

21. A liquid discharge recording head according to Claim 5, wherein said main body portion is provided with a plurality of liquid discharge ports, and a plurality of said pressure chambers corresponding to each of liquid discharge ports, respectively, and from the electrodes arranged for both sides of said piezoelectric film, at least those on one side are separated for installation corresponding to said pressure chambers in order to structure the piezoelectric vibrating portion for each pressure chamber.

22. A liquid discharge recording head according to Claim 21, wherein said piezoelectric film is separated to be arranged corresponding to said pressure chambers, and the electrodes on one side are formed on each of said separated piezoelectric film.

23. A liquid discharge recording head according to Claim 5, wherein the circumference of said piezoelectric vibrating portion is directly connected with the circumference of the pressure chamber without

using bonding agent or the like.

24. A method for manufacturing a liquid discharge recording head provided with the main body portion having liquid discharge ports, and pressure chambers with opening portion on part thereof, being connected with said liquid discharge ports, and piezoelectric vibrating portion installed to close said opening portion, comprising the following steps of:

forming vibrating plate and electrode on a substrate;

forming on said electrode a first layer having perovskite structure containing lead and titanium, and setting a temperature of 500°C or more when forming on said first layer a second layer having perovskite structure containing zirconium, lead, and titanium, and then, giving quick cooling from said temperature at least to 450°C with cooling speed of 30°C/min or more for forming piezoelectric film containing said first layer and second layer;

separating said piezoelectric film after the formation of said piezoelectric film corresponding to pressure chambers;

forming the upper electrode, and pressure chambers corresponding said separated piezoelectric films; and

bonding a nozzle plate having liquid discharge ports formed therefor,

wherein in the step of forming said piezoelectric film, said first layer is formed so as not to contain zirconium or so as to make the amount of contained zirconium smaller than that of said second layer.

25. A method for manufacturing a liquid discharge recording head provided with the main body portion having liquid discharge ports, and pressure chambers with opening portion on part thereof, being connected with said liquid discharge ports, and piezoelectric vibrating portion installed to close said opening portion, comprising the following steps of:

forming on a supporting substrate a first layer having perovskite structure containing lead and titanium, and setting a temperature of 500°C or more when forming on said first layer a second layer having perovskite structure containing zirconium, lead, and titanium, and then, giving quick cooling from said temperature at least to 450°C with cooling speed of 30°C/min or more for forming piezoelectric film containing said first layer and second layer, and forming on said supporting substrate the piezoelectric vibrating portion having said piezoelectric film;

bonding without using adhesive agent the circumference of said opening portion of said main body porion with the circumference of said piezoelectric vibrating portion by arranging them to be faced; and

removing said supporting substrate subsequent to said step,

wherein in the step of forming said piezoelectric vibrating portion, said first layer is formed so as not to contain zirconium or so as to make the amount of contained zirconium smaller than that of said second layer.

26. A method for manufacturing a liquid discharge recording head according to Claim 25, wherein said first layer, second layer, vibrating plate, and electrode are formed by the vapor method including sputtering and CVD method.

27. A method for manufacturing a liquid discharge recording head according to Claim 24, wherein a silicon substrate is used as said substrate, and said substrate is removed by etching using a mixed acid of hydrochloric acid and nitric acid to make the interior thereof pressure chambers.

28. A method for manufacturing a liquid discharge recording head according to Claim 27, wherein said substrate is removed by etching using hydrofluoric acid solution or potassium hydroxide solution.

29. A liquid discharge recording head according

to Claim 6, wherein the ratio of zirconium/titanium in said second layer is set at 30/70 or more and 70/30 or less.

30. A liquid discharge recording head according to Claim 6, wherein said piezoelectric film is mono-orientational crystal or monocrystal.

31. A liquid discharge recording head according to Claim 6, wherein said piezoelectric film is formed with orientation in the direction (100).

32. A liquid discharge recording head according to Claim 6, wherein said piezoelectric film is orientated in the direction (111), and the said electrodes are comb-shaped or formed on the entire face.

33. A liquid discharge recording head according to Claim 6, wherein said piezoelectric film is formed in a thickness of 10 μm or less.

34. A liquid discharge recording head according to Claim 6, wherein said piezoelectric film is formed in a thickness of 1 μm or more and 4 μm or less.

35. A liquid discharge recording head according

to Claim 7, wherein the ratio of zirconium/titanium in said second layer is set at 30/70 or more and 70/30 or less.

36. A liquid discharge recording head according to Claim 7, wherein said piezoelectric film is mono-orientational crystal or monocrystal.

37. A liquid discharge recording head according to Claim 7, wherein said piezoelectric film is formed with orientation in the direction (100).

38. A liquid discharge recording head according to Claim 7, wherein said piezoelectric film is orientated in the direction (111), and the said electrodes are comb-shaped or formed on the entire face.

39. A liquid discharge recording head according to Claim 7, wherein said piezoelectric film is formed in a thickness of 10 μm or less.

40. A liquid discharge recording head according to Claim 8, wherein said piezoelectric film is formed in a thickness of 1 μm or more and 4 μm or less.

41. A liquid discharge recording head according

to Claim 29, wherein the first layer of said piezoelectric film is formed in a thickness of 30 nm or more and 100 nm or less.

42. A liquid discharge recording head according to Claim 35, wherein the first layer of said piezoelectric film is formed in a thickness of 30 nm or more and 100 nm or less.

43. A liquid discharge recording head according to Claim 6, wherein said piezoelectric vibrating portion is provided further with a vibrating plate.

44. A liquid discharge recording head according to Claim 7, wherein said piezoelectric vibrating portion is provided further with a vibrating plate.

45. A liquid discharge recording head according to Claim 43, wherein said vibrating plate is formed by at least one of materials or a laminated member of the materials selected from nickel, chromium, aluminum, titanium, zirconium, and from the group of oxide thereof or nitride thereof, silicon, silicon oxide, polymer organic materials, and YSZ.

46. A liquid discharge recording head according to Claim 44, wherein said vibrating plate is formed by

at least one of materials or a laminated member of the materials selected from nickel, chromium, aluminum, titanium, zirconium, and from the group of oxide thereof or nitride thereof, silicon, silicon oxide, polymer organic materials, and YSZ.

47. A liquid discharge recording head according to Claim 43, wherein said vibrating plate is formed with the vibrating plate characteristics by ion injection on the upper part of the main body substrate to form pressure chambers.

48. A liquid discharge recording head according to Claim 44, wherein said vibrating plate is formed with the vibrating plate characteristics by ion injection on the upper part of the main body substrate to form pressure chambers.

49. A liquid discharge recording head according to Claim 43, wherein said vibrating plate is formed on a silicon monocrystal substrate with epitaxial development.

50. A liquid discharge recording head according to Claim 44, wherein said vibrating plate is formed on a silicon monocrystal substrate with epitaxial development.

51. A liquid discharge recording head according to Claim 6, wherein the second layer of said piezoelectric film contains niobium and tin, manganese, and provides antiferroelectricity.

52. A liquid discharge recording head according to Claim 6, wherein the electrode layers arranged for both side of said piezoelectric film are formed by platinum, iridium, conductive oxide, or conductive nitride.

53. A liquid discharge recording head according to Claim 6, wherein said main body portion is provided with a plurality of liquid discharge ports, and a plurality of said pressure chambers corresponding to each of liquid discharge ports, respectively, and from the electrodes arranged for both sides of said piezoelectric film, at least those on one side are separated for installation corresponding to said pressure chambers in order to structure the piezoelectric vibrating portion for each pressure chamber.

54. A liquid discharge recording head according to Claim 7, wherein the second layer of said piezoelectric film contains niobium and tin, manganese, and provides antiferroelectricity.

55. A liquid discharge recording head according to Claim 7, wherein the electrode layers arranged for both side of said piezoelectric film are formed by platinum, iridium, conductive oxide, or conductive nitride.

56. A liquid discharge recording head according to Claim 7, wherein said main body portion is provided with a plurality of liquid discharge ports, and a plurality of said pressure chambers corresponding to each of liquid discharge ports, respectively, and from the electrodes arranged for both sides of said piezoelectric film, at least those on one side are separated for installation corresponding to said pressure chambers in order to structure the piezoelectric vibrating portion for each pressure chamber.

57. A liquid discharge recording head according to Claim 53, wherein said piezoelectric film is separated to be arranged corresponding to said pressure chambers, and the electrodes on one side are formed on each of said separated piezoelectric film.

58. A liquid discharge recording head according to Claim 56, wherein said piezoelectric film is separated to be arranged corresponding to said pressure

chambers, and the electrodes on one side are formed on each of said separated piezoelectric film.

59. A liquid discharge recording head according to Claim 6, wherein the circumference of said piezoelectric vibrating portion is directly connected with the circumference of the pressure chamber without using bonding agent or the like.

60. A liquid discharge recording head according to Claim 7, wherein the circumference of said piezoelectric vibrating portion is directly connected with the circumference of the pressure chamber without using bonding agent or the like.